K^* production in Heavy Ion Collisions at RHIC

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Abstract

Study of resonances with their short life-times provides useful tools to probe the properties of hot and dense matter produced in relativistic heavy ion collisions. The high density and/or high temperature of the medium can modify resonance properties such as mass and width. Therefore, measurement of these properties can reveal important information about the evolution dynamics in heavy ion collisions. We report the measurements of K^* transverse momentum(p_T) spectra at mid-rapidity via its hadronic decay channel up to intermediate p_T of 2.9 GeV/c using the STAR detector in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}}$= 62.4 GeV and 200 GeV. These results are compared to previously reported K^* results from Au+Au collisions at RHIC. Integrated yield ratios of K^*/K and K^*/ϕ are used to understand the rescattering and regeneration effects on K^* production. PACS

1 Introduction

Ultrarelativistic heavy ion collisions are used to study the quantum chromodynamic the extreme conditions of high temperature and high energy density[1]. The K^*s h a very short life time ($\sim 4fm/c$) which is comparable to the expected life time of fireball created in heavy ion collisions[2, 5]. In the dense medium created, resonar are produced in close proximity with other strongly interacting hadrons, and hence in-medium effects related to the high density/or high temperature of the medium modify the characteristic properties such as masses, widths, and spectra shapes. Th fore, studies of resonance production mechanism can be a useful tool in understand the properties of the high density matter[2][3].

   Due to the short life time, some of the K^*s produced at hadronization can de in the medium before the kinetic freezeout, and are less likely to be reconstructed

These two competing processes determine the final K^* yield which depends on the t
elapsed between the chemical and kinetic freeze-out, the source size and the interac
cross section of daughter hadrons. Since the $\pi\pi$ total interaction cross section[7
significantly larger (about a factor ~ 5) than the πK total interaction cross-section
the final observable K^* yield in heavy ion collisions at RHIC is expected to be sma
than the primordial yield. This should be evident in a suppression of the K^*/K and
K^*/ϕ yield ratios in AA compared to elementary pp collisions at similar collision ene
Comparison of those ratios can then be used to roughly estimate the lower limit
the time difference between chemical freeze-out and kinetic freeze-out[2]. Centra
dependence of this suppression can be used to gauge the size of the fireball. The sys
size and energy dependence studies can shed additional light on the different in-med
effects, particularly the interplay between regeneration and rescattering mechanism

2 Experiment and Data Analysis

The primary tracking device, TPC(Time Projection Chamber) within STAR was u
to measure the K^* production via its hadronic decay channel. TPC provides the part
identification and the momentum information of the charged particles by measuring t
ionisation energy loss(dE/dx)[4]. The results discussed here are taken from Au+Au
$\sqrt{s_{NN}}$= 62.4 GeV and Cu+Cu collisions at $\sqrt{s_{NN}}$= 200 GeV and $\sqrt{s_{NN}}$= 62.4 GeV
RHIC.

Charged kaons and pions were selected from the primary tracks whose distanc
closest approach to the primary vertex have values less than 1.5 cm. The kaons
pions were selected requiring the dE/dx to be within two standard deviations(2σ) f
the Bethe-Bloch expectation for energy loss. Both the kaons and pions were require
have atleast 15 fit points for the tracks reconstructed inside the TPC and the rati
the number of fit points to the number of maximum possible fit points was greater t
0.55 to avoid selecting split tracks. Further kaon and pion tracks were selected v
both momentum and p_T greater than 0.2 GeV/c.

The unlike-sign Kπ invariant mass distribution was reconstructed from random c
bination of pairs from an event. The combinatorial background distribution was b
by using mixed-event technique where the unlike-sign Kπ invariant mass was obtai
from different events[9]. The data sample was divided into 10 bins in multiplicity
V_z position. The pairs from events in same multiplicity and vertex position bins w
selected for mixing to ensure that the event characteristic remain similar between
ferent events. The mixed event generated was normalized to subtract the backgro
in the same event unlike-sign invariant mass spectrum. The normalisation factor
evaluated by taking the ratio between the number of entries in the unlike-sign sa
event and mixed event distributions for invariant mass greater than 1.1 GeV/c as
pairs with invariant mass greater than 1.1 GeV are less likely to be correlated. A

Kπ mass resonant states and nonresonant correlations due to particle misidentifica[tion], which contribute significantly to the residual correlations near the signal. These [at]tributes are not present in the mixed event spectrum and thus the mixed event [subtraction] removes the uncorrelated background pairs from the unlike sign spectrum.
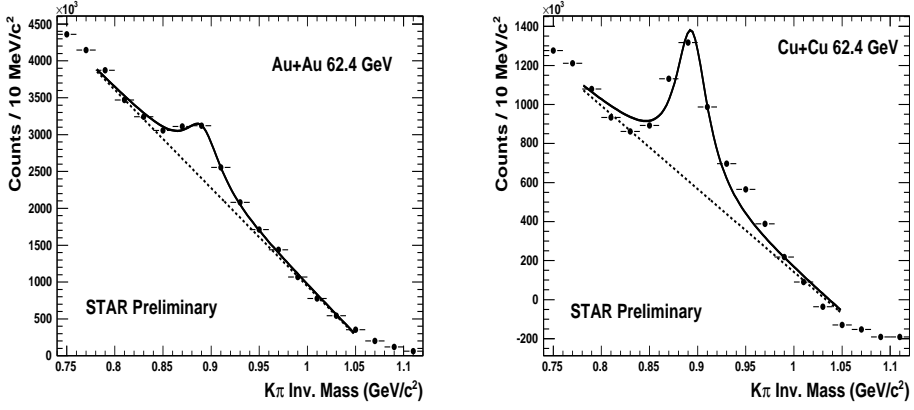

Figure 1: The Kπ pair invariant mass spectrum after mixed-event background subtrac[tion] tion fitted to SBW + RB. Left panel: Au+Au at 62.4 GeV Right panel: Cu+Cu at 6[2.4] GeV
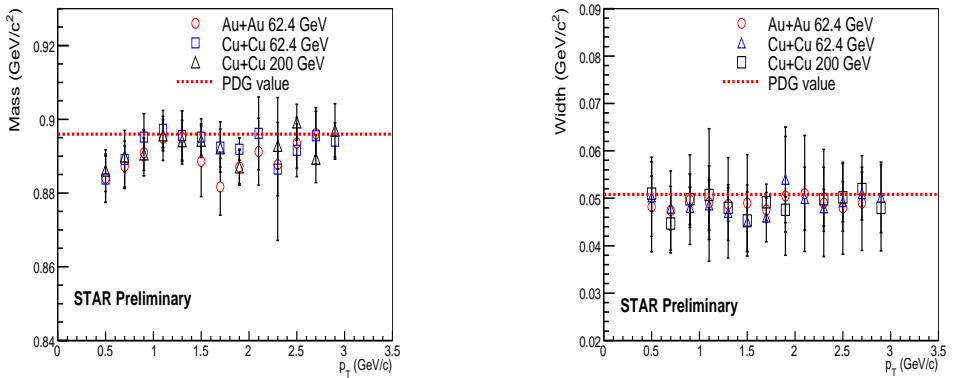
3   Results

Figure 2: K^{*0} mass (left panel) and width (right panel) as a function of p_T in minim[um] bias Au+Au collisions at 62.4 GeV and Cu+Cu collisions at 200 and 62.4 GeV. [The] solid line stand for the PDG values.

Figure 1 shows the unlike sign Kπ invariant mass spectrum after normalized mi[xed]

the non relativistic Breit wigner function and RBG is the linear function describing
residual background[2]. The variation of K^{*0} mass and width with respect to p_T
minimum bias Au+Au and Cu+Cu collisions is shown in Figure 2. Within the err
we do not observe a large difference in the measured K^{*0} mass from the PDG[10] va
for most of the p_T range studied. The K^{*0} width measured is comparable to the P
value.The systematic uncertainies in the mass and width were calculated by vary
the particle types, background subtraction functions and the dynamical cuts.

Figure 3 shows the K^* mid-rapidity transverse momentum spectra for different
tralities of Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}}$= 62.4 GeV. The raw spectra yie
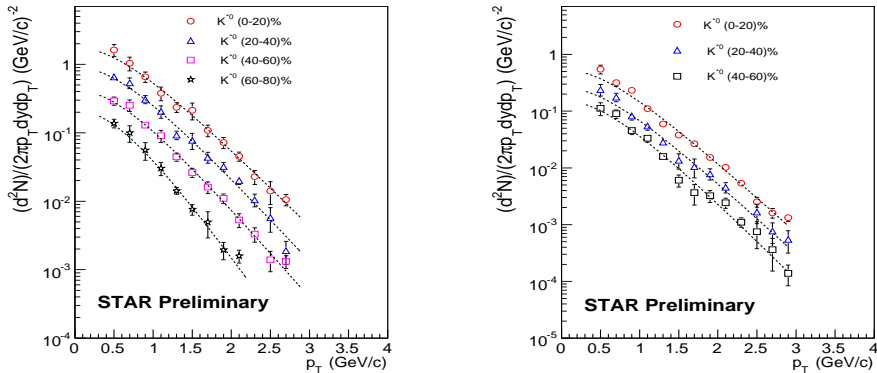corrected for efficiency and detector acceptance are well described by exponentia
function.

Figure 3: p_T spectra in Au+Au(left panel) and Cu+Cu(right panel)collisions at
GeV. The dashed line represents the exponential fit to data.

The K^{*0} yield at midrapidity is calculated from the data points in the measu
range and exponential fit was used to extract the yield outside the fiducial range.
K^{*0} invariant yield increases with number of participants in both Au+Au and Cu+
collisions. The systematic uncertainies on K^{*0} dN/dy is estimated by using differen
functions, particle types and dynamical cuts. The variation of measured K^* dN/dy v
respect to number of participants is depicted in Figure 4. The K^{*0} mean p_T was evalua
using the data points in the measured range of the p_T spectrum while assuming
exponential behaviour outside the fiducial range. The systematic uncertainity inclu
the differences between the direct calculation and from all other sources mentio
earlier. The K^{*0} mean p_T as a function of number of participants is shown in Figu
(right panel) for all the collision systems discussed. No significant centrality and sys
size dependence of mean p_T is observed for K^{*0} in Au+Au and Cu+Cu collisions
given colliding energy.

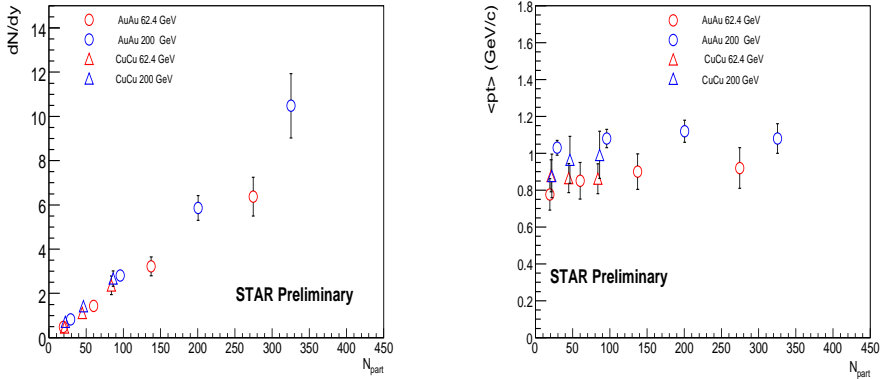The measurement of K^{*0}/K^- yield ratio can provide vital information on the

Figure 4: K^{*0} invariant yield (left panel) and mean p_T(right panel)as a function number of participants

collisons at the same beam energy [2, 5]. Figure 5(left panel) shows that $K^{*0}/$ ratio decreases with number of participants in Au+Au collisons at 62.4 and 200 G This may indicate that the rescattering effect is dominant over the regeneration ef and the fireball created in central collisions has comparatively larger lifetime than peripheral collisions. Similarly ϕ/K^{*0} ratio may also give us an idea on rescattering regeneration effect as both ϕ amd K^{*0} have same spin and similar mass but diff strangeness number and lifetime. In Figure 5(right panel), we observe that ϕ/K^{*0} r increases with number of participants in Au+Au collisons at 62.4 and 200 GeV favou the dominance of rescattering effect. Since ϕ and K^{*0} have different strangeness num the observed increase may be due to the possible strangeness enhancement in m central collisons.
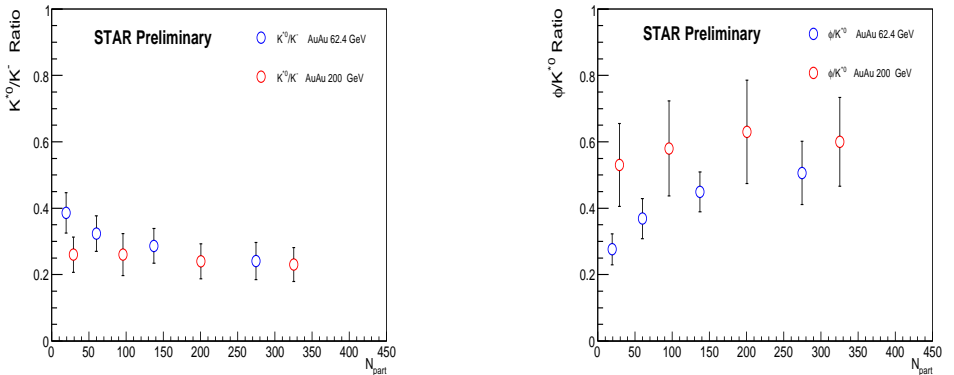

Figure 5: K^{*0}/K^- ratio (left panel)and ϕ/K^{*0} ratio(right panel) as a function of num of participants.

4   Summary

The preliminary results on the K^* production in Au+Au and Cu+Cu collisions measured with the STAR detector at RHIC at $\sqrt{s_{\mathrm{NN}}} = 62.4$ GeV and $\sqrt{s_{\mathrm{NN}}} = 200$ G are presented. The K^* integrated yield increases with number of participants in b Au+Au and Cu+Cu collision systems. No significant dependence of mean p_T on sys size is observed. The particle ratio measurement highlights the dominance of rescatte effect over the regeneration mechanism in K^* production in heavy ion collisions.

References

[1] J.Adams *et al.*, *Nucl.Phys.* **A 757**(2005) 102.

[2] J.Adams *et al.*,*Phys. Rev* **C 71**(2005) 064902.

[3] R.Rapp and J.Wambach,*Adv. Nucl.Phys.* **25** (2000) 1.

[4] K.H.Ackermann *et al.*,Nucl. Phys. **A 661**,681,(1999).

[5] Xin dong *et al.*,[STAR Coll.],QM2006 proceedings to appear International Jour of Modern Physics E

[6] M.Bleicher *et al.*, *Phys. Lett.* **B 530**, (2002) 81.

[7] S.D.Protopopescu *et al.*,*Phys. Rev.* **D 7**,1279(1973).

[8] M.J.Matison *et al.*,*Phys. Rev.* **D 9**,1872 (1974).

[9] C.Adler *et al.*,*Phys. Rev.* **C 66**(2002) 061901(R)

[10] Particle Data Group, Eur. Phys. J **C3**, 1-794 (1998)